Title: The Unidirectional Relationship of Nightmares on Self-Harmful Thoughts and Behaviors

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Abstract

Understanding the direction of the predictive relationship between nightmares and suicidal behaviors is important to model its underlying mechanisms. We examine the direction of this relationship and the mediating role of negative affect.

A fixed interval diary study obtained pre-sleep and post-sleep measures of affect, nightmares, and self-harmful thoughts and behaviors (SHTBs) from 72 university students (88.9% female).

The results show predictive utility of nightmares on SHTBs - indicating a four-fold increased risk of SHTBs. Additionally, results support the suggestion of a unidirectional predictive influence (of nightmares on likelihood of SHTBs but not vice versa). Moreover, post-sleep negative affect partially mediated the relationship between nightmares and post-sleep SHTBs. This empirically validates assumptions of directionality for future models.

Key words: Nightmares, Self-harm, Negative Affect

Introduction

Studies identifying various suicide risk factors have increased our ability to detect suicidal warning signs and informed prevention efforts (Borges et al., 2008). As such, examining modifiable risk factors and the underlying mechanisms linking such risk factors to self-harm is of crucial importance for further development of interventions and prevention strategies.

Amongst the recently discovered important risk factors are nightmares. These are vivid dysphoric dreams, intense enough to elicit awakening from REM sleep and allowing clear recall. Nightmares of a frequency and intensity akin to nightmare disorder (American Academy of Sleep Medicine, 2014) have be linked to increased suicidality (Bernert, Joiner, Cukrowicz, Schmidt, & Krakow, 2005; Cukrowicz et al., 2006). Importantly, nightmares have been identified as an independent risk factor for suicidal ideation (Bernert & Joiner, 2007), suicide attempts and repeat suicide attempts (Sjöström et al., 2007; Sjöström et al., 2009), and completed suicide (Tanskanen et al., 2001) above and beyond the effects of depressive symptoms. However, the majority of studies investigating the link between nightmares and suicidality have used cross-sectional designs (Bernert et al., 2005; Cukrowicz et al., 2006; Krakow et al., 2011; Nadorff, et al., 2011). As such, it is not clear whether nightmares precede or follow existing self-harmful thoughts and behaviors (SHTBs). Moreover, the retrospective assessment of nightmare occurrence over a certain time period in such studies is prone to underestimation. This is because nightmares, as with most dreams, may be forgotten or altered during re-interpretations, which may lead to false negatives. This has been verified by comparing of retrospective measurement with prospective dream logs (Zadra & Donderi, 2000). In order to establish a robust model of the relationship between nightmares and SHTB the key assumptions about the direction of the predictive relationship between these factors must be established. This is important because it has implications

concerning our understanding of the development of SHTBs over time and for developing interventions to promote recovery from them.

While it is ethically difficult to clearly validate the causal relationship between nightmares and suicidality by experimentally manipulating one of these variables, longitudinal studies can provide a preliminary indication of the direction of this relationship. Indeed, some studies have used longitudinal designs (Sjöström et al., 2009; Tanskanen et al., 2001); however, they have focused on establishing nightmares as a significant risk factor and did not explicitly investigate the direction of the relationship. Therefore, the main aim of the present study was to investigate the direction of the predictive relationship between nightmares and SHTBs using a longitudinal prospective diary in a student population while controlling for baseline levels of depressive symptoms.

Further, whilst nightmares have been shown to be a robust independent risk factor linked to SHTBs (Bernert & Joiner, 2007; McCall & Black, 2013), little is known about the mechanisms underlying this association. A recent review by McCall and Black (2013) has set out a model through which sleep disturbances, insomnia and nightmares, can lead to increased SHTBs, but these assumptions have not been empirically tested. Negative affect has been described as playing a pivotal role in the association between nightmares and suicidal behaviors (Cukrowicz et al., 2006; Bernert & Joiner, 2007). It has been suggested that nightmares disrupt the normal emotion regulatory process of dreaming (Nielsen & Levin, 2007, 2009), and thus lead to negative affect. In line with this, research has demonstrated that nightmares are associated with increased negative affect post-sleep (Antunes-Alves & de Koninck, 2012); however, these studies have not linked this association to the occurrence of SHTBs. Therefore, the secondary aim of the present study was to investigate the role of negative affect as a pivotal underlying mechanism in the association between nightmares and SHTBs.

Aims and hypotheses

The present study investigates the (i) direction of the predictive relationship between nightmares and SHTBs, and (ii) the effects of negative affect in mediating this association by longitudinally tracking the occurrence of nightmares, and pre- and post-sleep negative affect and SHTBs. Moreover, whilst previous studies focused on suicidal behaviors, clearly implying suicidal intent, the current study investigated the relationship between nightmares and self-harm behaviors regardless of suicidal intent. Here, self-harm was operationalized as intentional self-injury or self-poisoning, regardless of motivation or suicidal intent and with a non-fatal outcome (Hawton et al., 2003). The above definition of self-harm assumes self-harm to occur with suicidal intent on a continuum. This conceptualization was selected over one which dichotomizes suicidal intent such as non-suicidal self-injury and suicide attempts due to the changing motivations of self-harm within and between episodes (Hjelmeland et al., 2002; Rodham, Hawton & Evans, 2004), frequent reports of ambivalence associated to self-harm (Hawton, Cole, O'Grady & Osborne, 1982) , and the relatively weak evidence base for a clear dichotomy of suicidal intent due to a lack of taxometric studies (Kapur et al., 2013). Moreover, a continuum approach was selected to incorporate self-poisonings as a self-harm method which is not included in definitions of non-suicidal self-injury (Andover, Morris, Wren & Bruzzese, 2012). Based on previous research and proposed theoretical models (Bernert & Joiner, 2007; Anutnes-Alves & de Koninck, 2012) we hypothesized that:

i.   The occurrence of nightmares will significantly increase the likelihood of SHTBs post-sleep, even after controlling for depressive symptoms, pre- and post-sleep negative affect and pre-sleep SHTBs.

ii.   Post-sleep negative affect will mediate this association between nightmares and post-sleep SHTBs.

Methodology

Design and procedure

A 2-stage study was performed. Stage 1 comprised a large cohort psychometric study used to recruit participants for stage 2 (the present diary study). The stage 1 online questionnaire assessed participants' self-harm history, depressive symptoms, and sleep quality no more than one week prior to participants starting the diary study protocol. The history of engagement in self-harm regardless of intent was obtained to distinguish and model responses obtained during the diary phase of the study according to self-harm history, given that participants with an existing history of self-harm are more likely to exhibit SHTBs. A 5 day fixed interval diary study design was implemented for stage 2. Participants completed daily pre-sleep and post-sleep measures relating to SHTBs, negative affect and the occurrence of nightmares using pen and paper diaries. This study utilized daily prospective dream logs to reduce recall biases associated with retrospective designs (e.g., underestimation of nightmares; Zadra & Donderi, 2000). The study protocol was augmented by daily automatic Short Message Service (SMS) text message reminders pre-sleep (prior to the average bed-time indicated on the PSQI) and post-sleep at an agreed wake up time. Reminders were sent to participants for the duration of their participation in the study.

Participants attended a thorough compulsory training session on diary completion stressing the importance of accurate timely responses. Additionally, clear definitions of self-harm behaviors (Hawton et al., 2003) and nightmares (American Academy of Sleep Medicine, 2001) were provided along with examples (i.e. a sample diary entry and the DSHI list of self-harm behaviors). They were requested to complete the diary for 5 consecutive weekdays, providing 5 pre-sleep and 5 post-sleep entries per participant. They were instructed to complete the pre-sleep section of the diary immediately (or no more than 1 hour) prior to going to sleep; and the post-sleep section as soon as they woke up (or no more than

one hour after waking). Participants were required to date and time the completion of individual pre- and post-sleep diary entry sheets and submit those daily using the provided researcher-addressed internal mail envelopes. These were to be handed in directly to a collection box by 1pm on the day of 'post-sleep section' completion. If participants could not hand their entries at the collection box, they were to notify the researcher via text message by 1pm having submitted their entry via the university internal mailing system. Entries which were not submitted in time were excluded.

Ethics Statement

This study was approved by the University of Nottingham School of Psychology ethics committee. Written consent was obtained from all participants for the both the online assessment and diary section of the study. Written debriefing information and contact details for relevant support groups dealing with issues explored in the present study were provided to all participants.

Participants

Three hundred and ninety-nine (64 males) university students completed the stage 1 online assessment questionnaire. Of those, 113 agreed to take part in stage 2 (diary study). The remaining 286 participants did not respond to an invitation to the diary completion training[1]. Of the 113 who attended the training, 36 participants were excluded as they did not return any diary entry within the specified times. A further 5 participants were excluded as they reported the current use of antidepressant medication or sleeping issues other than nightmares more than 'Once or twice a week' on the PSQI. This was to control for artificial

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[1] There were no significant differences between participants who responded to invitation for stage 2 (diary study) and those who did not on age ($p>.05$) and depressive symptoms ($p>.05$).Moreover, while fewer male participants responded to invitations (15.1%) compared to those who did not respond (17.5%), this proportional difference is not significant. However, significantly more individuals with a history of self-harm than without responded to invitations ($p<.05$).

conflation of nightmare occurrences (Pagel & Helfter, 2003) and substantial levels of confounding sleep co-morbidities.

A total of 72 participants (8 males) aged between 18-32 years ($M = 21.04$, $SD = 3.40$) completed at least one full diary entry (pre- and post-sleep). Of those, 43 participants (5 males) reported a history of self-harm engagement. Participants were naïve to the aims of this study. Research credits were granted to participants in exchange for participation.

Measurements

Online Assessment Measures:

Question 5 of the *Pittsburgh Sleep Quality Index* (PSQI; Buysse et al., 1989) was used to assess potential co-morbid sleep disturbances which could confound findings relating to nightmares (Nielsen & Levin, 2009). The questionnaire is comprised of 10 open ended items (e.g. inability to fall sleep within 30mins, difficulties breathing, pain during sleep) assessing frequency of sleep disturbances over the last month on a 4-point rating scale (from 0 – *'not during the past month'* to 3 – *'three or more times a week'*). Responses on these items of more than 'once or twice a week' (>2) were used as exclusion criterion for the current study.

The *Beck Depression Inventory-II* (BDI-II; Beck et al., 1996a) was used to assess the presence and severity of depressive symptoms over the last two weeks. It comprises 21 items scored on a 4-point scale with higher scores indicating greater levels of depressive symptoms. The BDI-II has good reliability (Cronbach's alphas = .91) and validity (Beck et al., 1996b) and was used to control for the impact of depressive symptoms in the current study.

The *Deliberate Self-Harm Inventory* (DSHI; Gratz, 2001) was used to assess participants' self-harm history over the lifetime. Seventeen dichotomous items assessed self-harm behaviors (No/Yes). Participants responding positively to any of the 17 items were categorized as having a history of self-harm (SH group) while those reporting no self-harm behaviors were categorized as no history of self-harm (no SH group). The DSHI assesses

self-harm behaviors corroborated by clinical observations and shows good internal consistency and, convergent and discriminant validity (Gratz, 2001). The original DSHI (Gratz, 2001) explicitly measures acts of self-harm without conscious intent to die, non-suicidal self-injury. As this study investigates the link between nightmares and SHTBs in individuals with a history of self-harm regardless of intent or motivation to die, the instructions to participants were modified to encompass all acts of self-harm by removing any mention of suicidal intent. We followed the modifications performed by Lundh et al. (2007) who modified the DSHI to study concrete instances of self-harm without focusing on retrospective introspection of intent. The DSHI used the present study displayed good levels of reliability (Cronbach's alphas = .80).

Diary Measures:

Each *Diary Entry* consisted of separate pre-sleep and post-sleep sections, printed in booklet format on one A4 page. Each time section was located on one side of the booklet. Both sections included the *Positive Affect and Negative Affect Schedule-Short Form* (PANAS-SF; Thompson, 2007) to assess pre- and post-sleep mood. The Negative Affect subscale (Cronbach's alphas = .76) was used in the present study to measure fluctuation in pre- and post-sleep negative affect. Mood measures were followed by 2 questions relating to presence or absence of self-harmful thoughts (*'have you had thoughts of deliberately injuring yourself?'*) and self-harm acts (*'have you deliberately injured yourself?'*) with a dichotomous answer format (Yes/No). Pre-sleep questions prefixed the SHTB questions with "today" while post-sleep questions stipulated "since waking up". The post-sleep section comprised an additional question asking participants if they had experienced a memorable negative or dysphoric dream that elicited awakening (Yes/No) and some additional space underneath for verbal descriptions of the content of nightmares.

The variables *'pre-sleep SHTBs'* and *'post-sleep SHTBs'* were computed by pooling together diary items pertaining to presence of self-injurious thoughts and presence of self-injurious acts at their respective time points resulting in binary variables (SIBTs present/not present) for each day of the study resulting in 5 entries of pre-sleep SHTBs and 5 post-sleep SHTBs per participant. Similarly, occurrence of *'nightmares'* was computed as a binary (No/Yes) variable. Negative affect (NA) scores for each entry section were computed following PANAS-SF scoring guidelines providing average mood scores for *'pre-sleep NA'* and *'post-sleep NA'*.

Statistical analysis

Generalized Estimating Equations (GEE; Liang & Zeger, 1986; Zeger & Liang, 1986) - a subtype of generalized linear modeling - were used to analyze the data. While hierarchical linear models (HLM) are typically preferred for analyses of data with longitudinal clustering, the assumptions of normality required to obtain accurate estimates were not met. In addition, the intended hierarchy for the present models specified originally individual diary entries at level one, clustered within participants at level two, and nested within self-harm history groups at level three, which lends itself to HLM analysis. However, exploration of the data revealed a complete separation of post-sleep SHTBs based on self-harm grouping. Therefore, a 3 level HLM analysis would have been unsuitable due to impaired model convergence. GEE presented an alternative as it produces efficient and unbiased regression estimates when analyzing longitudinal data with non-normal response variables (e.g. binomial), and can be used to compute model with 2 levels of hierarchy (Ballinger, 2004). Analyses were performed using IBM SPSS Statistic v.21 (IBM Corporation, 2012).

In order to identify directionality of effects and rule out alternative relationships, three potential pathways were tested: *i)* whether nightmares significantly increased the likelihood of reporting post-sleep SHTBs; *ii)* whether SHTBs pre-sleep significantly increased the

likelihood of experiencing nightmares; *iii)* whether SHTBs pre-sleep significantly increased the reporting of SHTBs post-sleep regardless of nightmares.

Pathways *'i'* and *'iii'* were tested simultaneously within one model. The GEE model was specified to use logit link function with a binomial distribution as the dependent variable (presence of post-sleep SHTBs) was binary (SHTBs vs. no SHTBs). The reference category was set to 'first' thus providing estimates relating to presence of SHTBs. Predictive factors entered into the model were pre-sleep SHTBs and nightmares. Pre-sleep negative affect (pre-sleep NA), post-sleep negative affect (post-sleep NA) and depressive symptoms were entered as covariates. To test pathway *'ii'*, the GEE model was specified to use a logit link function with nightmares entered as the dependent variable. The predictive factor was pre-sleep SHTBs with pre-sleep NA and depressive symptoms entered as covariates. For both models the correlation structure was set to auto-regressive AR(1) and hybrid method was used with 95% maximum likelihood confidence interval (CI). Main effects for all variables were sought.

Mediation analysis (Hayes, 2013) was performed testing the mediating effect of post-sleep negative affect on the relationship between nightmares and post-sleep SHTBs while controlling for depressive symptoms, pre-sleep negative affect and pre-sleep SHTBs.

Results

Attrition rates and descriptive statistics

A 13.9% attrition rate was observed over the course of the study for the whole sample as participants did not complete all diary entries or their entries did not meet the study inclusion criteria. A total of 328 out of the potential 360 diary entries were obtained over the course of the study. Over the 5 day period, 39 counts (11.9%) of pre-sleep SHTBs were recorded from 16 participants, while post-sleep SHTBs were reported 19 times (5.8%) by 11 individuals. Nightmare occurrence was reported 47 times (14.3%) by 32 participants.

Descriptive statistics are reported in Table 1. Means and standard deviations (SD) are provided for pre-sleep and post-sleep negative affect, frequency counts are provided for categorical data. Pre-sleep and post-sleep SHTBs as well as nightmares were reported by participants with a history of self-harm throughout the 5 days of the study. Two occurrences of pre-sleep SHTBs were also reported by two participants without a history of self-harm on day 3 and 4. Participants reporting a history of self-harm (M= 21.02, SD= 3.43) and those without (M= 21.07, SD= 3.35) did not significantly differ in age (p> .05). However, participants reporting a history of self-harm (M= 18.70, SD= 10.24) had significantly higher levels of depressive symptoms than participants with no self-harm (M= 10.28, SD= 6.88), $t(70)$= 3.87, p<.001. Moreover, those reporting a history of self-harm experienced significantly more nightmares ($\chi^2 (1) = 5.53$, p< .05), pre-sleep negative affect ($t(326)$= 3.18, p< .01), post-sleep negative affect ($t(326)$= 3.24, p= .001), pre-sleep SHTBs ($\chi^2 (1) = 23.73$, p< .001) and post-sleep SHTBs ($\chi2 (1) = 14.11$, p< .001).

Due to the gender imbalance in the sample, pre-analysis checks on study variables were performed. There were no significant differences between males and females on depressive symptoms ($t(70)$= .80, p> .05), pre-sleep negative affect ($t(326)$= 1.15, p> .05), post-sleep negative affect ($t(326)$= .18, p>.05), nightmares ($\chi^2 (1) = .02$, p> .05), pre-sleep SHTBs ($\chi^2 (1) = .27$, p> .05) and post-sleep SHTBs ($\chi2 (1) = .51$, p> .05).

(*******Insert Table 1 here******)

Exploring predictive pathways 'i', 'ii', and 'iii'

The models were estimated for the full sample using all available diary entries[2]. Estimation parameters are displayed in Table 2.

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[2] Estimates were additionally obtained for the self-harm history subsample (n=43, diary entries n= 193) as descriptive data indicated post-sleep SHTBs to only occur in those with a history of self-harm. The estimates for this subsample mirrored those reported above. i.e., the occurrence of nightmares significantly increased the likelihood of post-sleep SHTBs ($\chi^2 (1) = 4.19$, p= .041) by 4.01 times (95% C.I. [1.06 – 15.15], p<.05).

The first model, examining pathways '*i*' and '*iii*' simultaneously indicates that, as hypothesized, nightmares could significantly predict post-sleep SHTBs (χ^2 (1) = 3.92, *p*< .05) beyond depressive symptoms, pre-sleep negative affect, and post-sleep negative affect providing support for pathway '*i*'. Nightmares significantly increased the risk experiencing post-sleep SHTBs. However, pre-sleep SHTBs did not significantly predict the occurrence of post-sleep SHTBs (χ^2 (1) = 1.10, *p*>.05) beyond the effects of depressive symptoms, pre-sleep negative affect, and post-sleep negative affect; thus failing to support pathway '*iii*'. Similarly, model 2, examining pathway '*ii*', indicates that pre-sleep SHTBs did not significantly predict nightmares (χ^2 (1) = .08, *p*>.05) beyond the effects of depressive symptoms and pre-sleep negative, thus further failing to support pathway '*ii*'.

<div align="center">(*******Insert Table 2 here******)</div>

Mediation of nightmares and post-sleep SHTBs by post-sleep negative affect

The mediating effect of post-sleep negative affect on the relationship between nightmares and post-sleep SHTBs while controlling for depressive symptoms, pre-sleep negative affect and pre-sleep SHTBs is represented by Figure 1. Path *a* represents the direct effect of nightmares on the mediator (post-sleep NA). Path *b* represents the direct effect of the mediator on post-sleep SHTBs. Path *c* (*B* = 2.03, *S.E.* = .63, *Z* = 3.24, *p*=.001) shows the total effect of nightmares on post-sleep SHTBs mediated by post-sleep negative affect. Path *a* (*B* = 2.23, *S.E.* = .46, *Z* = 4.85, *p*<.001) was significant and positive as was path *b* (*B* = .22, *S.E.* = .10, *Z*= 2.29, *p*=.02) indicating that the occurrence of nightmares were related to increased post-sleep negative affect; this negative affect in turn was associated to increased risk of post-sleep SHTBs. The indirect effect of nightmares on post-sleep SHTBs through post-sleep negative affect is represented by *a* × *b*. The normal theory test for this indirect effect was significant (*B* = .49, *S.E.* = .31, *Z*= 2.04, *p* = .042). Although a significant reduction of the direct (*c*) path coefficient was observed, the direct effect path *c'* remained

significant and greater than zero (B = 1.48, *S.E.* = .68, *Z*= 2.20, *p* = .028, [95% C.I. bias corrected .16 to 2.81]) indicating this mediation to be partial.

(*******Insert Figure 1 here*******)

Discussion

The present study aimed to clarify the direction of the predictive relationship between nightmares and SHTBs using a prospective longitudinal diary study design. The rationale was to empirically test theoretical models which assume that nightmares are predictive of SHTBs (McCall & Black, 2013). Though this association has been demonstrated in the literature (Tanskanen et al., 2001; Bernert & Joiner, 2007; Sjostrom et al., 2007, 2009; Nadorff et al., 2011), the direction of the effect had yet to be explicitly examined. Testing three potential pathways of this association, our findings provide clear empirical support for the hypothesis that nightmares predict likelihood of post-sleep SHTBs. Having had a nightmare was the strongest predictor of post-sleep SHTBs. In a model accounting for depressive symptoms and negative affect, the risk of SHTBs was four times greater compared to nightmare-less sleep. Our findings do not support the alternative pathways, suggesting that occurrence of pre-sleep SHTBs did neither increase the risk of nightmares nor the risk of post-sleep SHTBs. Conjointly these findings support a unidirectional predictive relationship between nightmare and SHTBs.

Furthermore, a mediation analysis suggested that nightmares lead to post-sleep negative affect, which in turn leads to SHTBs. This is in line with the notion that nightmares act as emotion dysregulators, hindering the normal mood regulatory process of dreaming leaving the nightmare sufferer with increased negative affect upon waking (Bernert & Joiner, 2007; Nielsen & Levin, 2007, 2009). These results highlight the importance of taking negative affect into account when modeling the association between nightmares and SHTBs. Moreover, it supports the ecological momentary assessment of Nock et al. (2009) which

indicated that elevated negative affect precede instances of non-suicidal self-injury. However, the mediating effect of negative affect was only partial, suggesting that there are further mechanisms that need to be explored. For instance, McCall and Black (2013) suggested that hyperarousal may mediate the relationship between nightmares and suicidal behaviors. Moreover, it has been suggested that experiencing a nightmare may lead to greater sensitivity to cues and emotions lowering distress tolerance (Cukrowicz et al., 2006). As such, future studies should investigate the role of hyperarousal and increased sensitivity to environmental cues in increasing the risk of SHTBs while also considering negative affect. This combination of arousal and negative emotions may yield better explanatory power in theoretical models linking sleep disturbance and suicidal behavior (e.g., McCall & Black, 2013).

The findings of the current study that nightmares predict likelihood of post-sleep SHTBs (after controlling for depressive symptoms, pre- and post-sleep negative affect) suggest that nightmare-less sleep is protective against SHTBs. Indeed, Nock and colleagues (2009) had previously found that individuals who engage in self-harm use sleep as an alternative affect regulation strategy when experiencing urges to self-injure. Furthermore, it suggests that nightmares may be an important risk factor for self-harm engagement. This is supported by the complete separation of post-sleep SHTBs according to self-harm history (only those with a history of self-harm reported post-sleep SHTBs – see footnote 2). The increased risk of post-sleep SHTBs in participants with a history of self-harm following the occurrence of nightmares and high negative affect could indicate that self-harming individuals, who suffer from deficits in affect regulation (Klonsky, 2009), may do so not only during their waking life but throughout the diurnal cycle. Thus, nightmares may be of clinical predictive utility for those who have a history of self-harm. However, the predictive utility of nightmares for non-self-harm participants is likely to be limited. Ribeiro, Silva, & Joiner

(2014) have shown that overarousal symptoms (such as nightmares) and acquired suicidal capability (such as self-harm history) interact to predict further suicidality. The complete separation of post-sleep SHTBs exhibited by our sample would therefore be congruent with findings of Ribeiro et al. (2014) whereby a nightmare without acquired capability (self-harm history) would fail to elicit subsequent suicidality (post-sleep SHTBs) due to a lack of an interaction effect. The findings of Nock and colleagues, in combination with those of the present study, provide support towards a rationale for the treatment for nightmares in individuals who are experiencing problems with self-harm. This echoes calls from within the literature (Krakow et al., 2011) for nightmare reducing treatments such as Imagery Rehearsal Therapy (Krakow & Zadra, 2010) which may aid affect regulation during sleep and could potentially reduce SHTBs.

Although supportive of the literature and of the pathway which hypothesized nightmares to predict SHTBs experienced in the post-sleep period, our results must be interpreted with caution for several reasons. Firstly, the observational nature of this study does not allow us to validate any potentially causal relationship between nightmares and SHTBs. Whilst they allow us to draw conclusions about the direction of the relationship, the replication and validation of these findings by way of experimental manipulation (reduction) of nightmares may further our understanding of the potential causal mechanisms. If an intervention using robust randomized controlled trial methods resulted in a reduction in nightmares and a reduction in SHTBs (as compared to a control group with no change in nightmares or SHTBs), this would provide strong evidence for the existence of a causal relationship between nightmares and SHTBs. Nevertheless, a strength of the present study is the prospective nature of data collection which provides a more accurate estimate of nightmares than those generated in studies which have collected these data retrospectively (Zadra & Donderi, 2000).

However, the pen and paper methodology used, although augmented by text message reminders, does not guarantee that participants completed the diary in the time indicated on the entries. While this method has been used widely in the psychological literature (Bolger et al., 2003) and efforts were made to reduce the impact of non-compliance using a variety of techniques (extensive instructions given during briefing, text message prompts, increasing participant engagement via descriptions of nightmares, and the excluding entries submitted past a daily deadline), it remains possible for participants to have completed an entry just prior to submitting it, reducing the accuracy of pre-sleep and post-sleep measures. Concurrently, the study's temporal restrictions (instructing participants complete the post-sleep measure soon as they woke up or no more than one hour after waking) may have resulted in an underestimation of post-sleep SHTBs as participants completing the diary as instructed had only one hour to experience SHTBs. While potentially reducing the frequency of SHTBs logged, limiting SHTBs reporting to one hour after waking aimed to increase confidence that any SHTB was linked to the occurrence of nightmares, and to reduce the impact of confounding events (negative post-sleep event unrelated to nightmare) on the occurrence of post-sleep SHTBs. A 24hr recording period would allow for a higher frequency of SHTBs to be reported. However, such methodology is likely to increase participation burden and increase attrition rates.

Although pen and paper method selected to ease participation for a wider range of individuals by eliminating technological limitations (e.g., internet access or connection, computer literacy, or smartphone availability for diary apps) future studies could benefit from providing Personal Digital Assistants (PDAs) which provide clear time locking information and improve the validity of findings.

The generalizability of our findings to the wider population must be undertaken with caution. Although pre-analysis checks revealed no significant differences between genders on

study variables and the imbalance is consonant with the trends reported in the literature (Hawton et al, 2007), the proportion of females (ratio of 8:1) in our undergraduate sample remains high for the sample age group. Moreover, due to group imbalances, statistical checks performed were underpowered and cannot fully alleviate concerns with of generalizability. This is of importance as Lundh et al. (2013) have shown poor sleep to be a risk factor for non-suicidal self-injury in adolescent females but not in males. A degree of self-selection bias is also apparent in the sample as demonstrated by the attrition rate from screening questionnaire (n=399) to diary participation (n=72), with the remaining participants exhibiting high rates of self-harm history (60% of final sample). As participants with a history of self-harm reported significantly more nightmares, it may be that these participants were more willing to take part to obtain some degree of self-understanding regarding their nightmares and self-harm engagement.

Additionally, the short period of the present study may be reflective of weekday behavior specifically. Therefore, future studies should aim to address the gender imbalance to be more in line with self-harm gender ratios reported in the literature and extend the duration of the diary allowing findings to be generalizable to a greater length of time. An increase in sampling duration would also reduce the potentially confounding effects of reactive assessment, allowing for an adjustment period which could be discounted from the analysis. As the effects of aging on nightmares during adulthood are ambiguous; with some studies indicating frequency reduction (Nielsen, Stenstrom, & Levin, 2006; Schredl, 2013), increases (Sandman et al., 2013), or no change (Schredl, 2010); replication with a variety of ages would be useful to see if the effect of nightmares on SHTBs remains across the life-span. Age-related variation in this relationship could inform potential interventions allowing for vulnerable groups to be targeted, thus maximizing impact.

The DSHI (Gratz, 2001) used to assess self-harm history was modified similarly to Lundh et al. (2007) to encompass all acts of self-harm regardless of intent. While our scale indicated good internal reliability (α=.80) this modification may result in changes to the validity and test-retest reliability of the instrument and should be considered when assessing the findings of this study in relation to individuals with a history of self-harm. Specific measurement of suicidal intent and their relation to a range of sleep issues is therefore recommended.

Previous research has shown that poor sleep or insomnia is a risk factor for the development of suicide (Fujino et al., 2005), suicidal ideation (McCall et al. 2010), and self-injury (Lundh, Bjärehed, & Wångby-Lundh, 2013). While it is possible that sleep issues that were not measured in the present study confound our results, our study aimed to limit confounding sleep disorders by excluding individuals with frequent sleep difficulties other than nightmares. Further research is required where sleep disorders (e.g., insomnia, nightmare disorder, sleep apnea) are assessed with validated measurement tools. This would reduce conflation of multiple sleep disorders as risk factors for suicidal behaviors due to the similarities in symptoms (e.g. awakening in both insomnia and nightmares).

The direction of the predictive relationship between nightmares and SHTBs was explored here in order to empirically validate theoretical assumptions regarding the directionality of the association between nightmares and SHTBs. While replication is recommended with diverse samples, technologically enhanced methodology, and stringent assessment tools; this study provides preliminary evidence supporting the premise that nightmares are predictors of SHTBs and that this relationship is unidirectional. Cukrowicz et al. (2006) and Bernert and Joiner (2007) suggested that a mechanism associating nightmares to suicidal behavior would incorporate dysregulated mood. Our results support their suggestion showing post-sleep negative affect directly predicts post-sleep SHTBs and

partially mediates the relationship between nightmares and post-sleep SHTBs. Importantly, Nightmares as a risk factor of SHTBs are amenable to interventions. As such, nightmare reducing treatments for individuals with a history of self-harm engagement should be considered and assessing their effectiveness in reducing SHTBs is likely to be a promising avenue for future research.

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Table 1 – Descriptive statistics for the days of diary completion

	Evening SHTBs	Nightmares	Morning SHTBs	Evening NA Mean (SD)	Morning NA Mean (SD)
Day 1 (n=72)	7 (9.7%)	13 (18.1%)	4 (5.6%)	7.72 (3.06)	7.28 (2.68)
Day 2 (n=68)	10 (14.7%)	8 (11.8%)	5 (7.4%)	7.97 (2.89)	7.28 (3.05)
Day 3 (n=64)	6 (9.4%)	13 (20.3%)	4 (6.3%)	7.80 (3.30)	7.28 (2.99)
Day 4 (n=62)	8 (12.9%)	9 (14.5%)	3 (4.8%)	7.39 (2.98)	7.20 (3.13)
Day 5 (n=62)	8 (12.9%)	4 (6.5%)	3 (4.8%)	7.94 (3.26)	6.98 (2.75)

Table 2 – GEE model 1 and 2 testing pathways *'i & iii', and 'ii'* respectively

	Parameter*	Beta (S.E.)	Odds Ratio (95% C.I.)	*p*
GEE Model 1 †	*Depressive symptoms*	.15 (.03)	1.16 (1.10 to 1.23)	<.001
	Evening SHTBs	.53 (.51)	1.70 (.63 to 4.62)	.295
	Evening NA	-.07 (.10)	.94 (.77 to 1.14)	.511
	Nightmares	1.43 (.72)	4.17 (1.02 to 17.11)	.048
	Morning NA	.20 (.10)	1.22 (1.00 to 1.49)	.046
	†Dependent variable = morning SHTBs, Reference category = no SHTBs			
GEE Model 2 ‡	*Depressive symptoms*	.01 (.02)	1.01 (.97 to 1.05)	.968
	Evening SHTBs	-.14 (.49)	.87 (.33 to 2.28)	.779
	Evening NA	.18 (.07)	1.20 (1.07 to 1.34)	.001
	‡Dependent variable = nightmares, Reference category = no nightmares			

*Redundant parameters (categorical independent variable's reference category) have been omitted
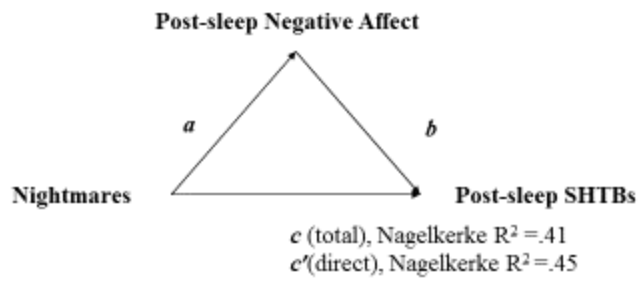
Figure 1 – Partial mediation of the effect of Nightmares on Post-sleep Self-Harm Thoughts and Behaviors (SHTBs) by Post-sleep Negative Affect.